Using scatterometer-measured vector winds to study high-impact weather events

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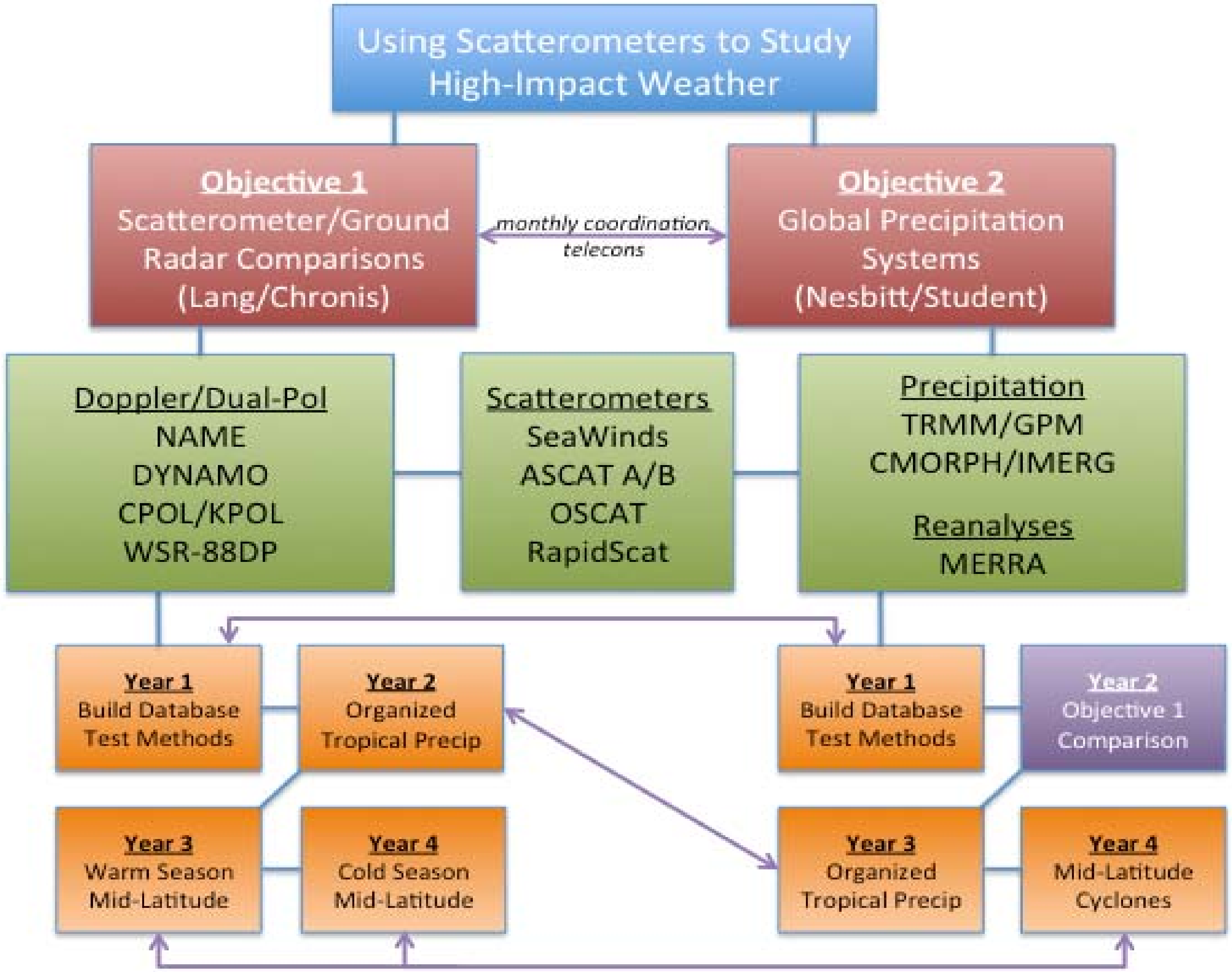
<u>Motivation</u>

- Little is known as to the association between extreme precipitation/wind producing oceanic weather systems and synoptic-scale to mesoscale surface wind features, due to the paucity of observations

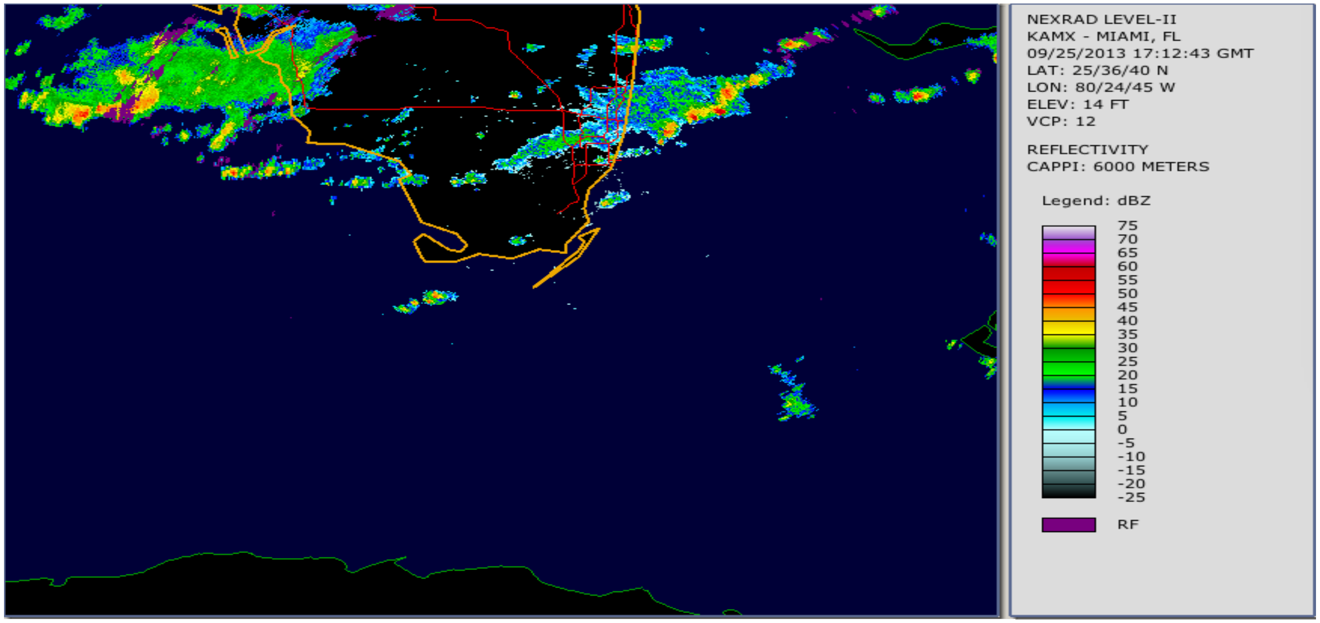
<u>Main Science Goals</u>

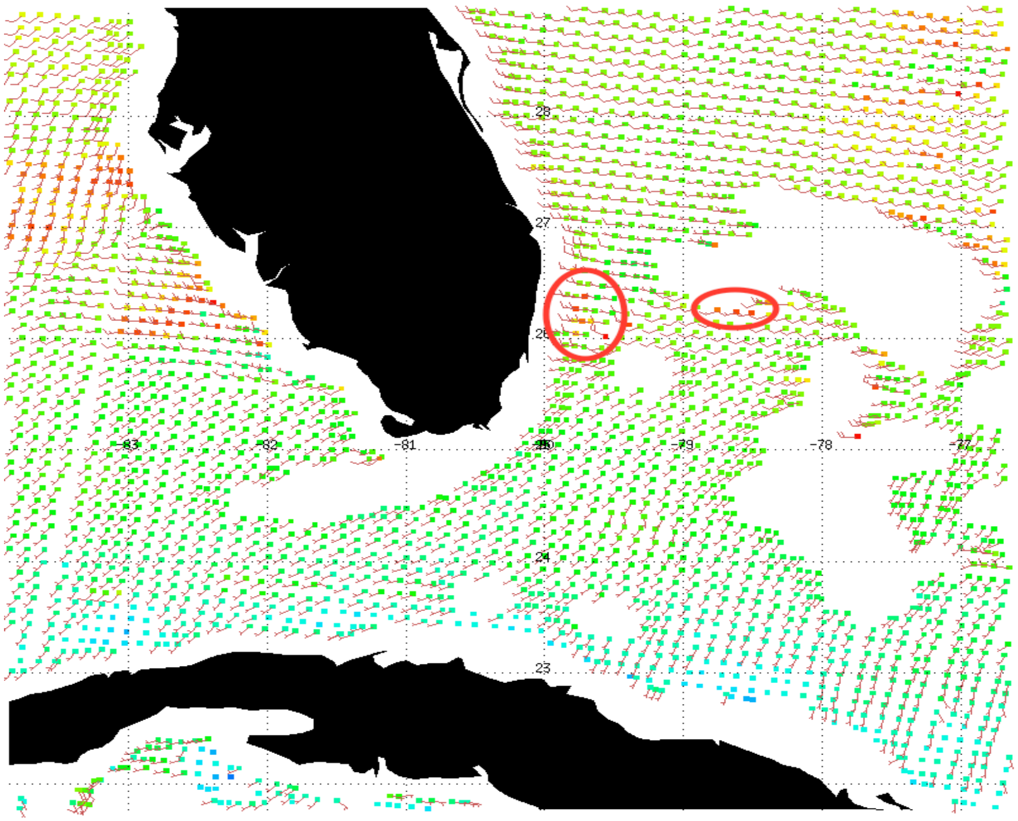
- Investigate the utility of vector wind retrievals from space-based scatterometers during high-impact weather events
- Use these data to study the influence of surface features (e.g., frontal boundaries, moisture convergence, etc.) in their development and evolution.

"High Impact Weather Events" = organized mesoscale systems producing significant winds and heavy precipitation



Using Scatterometers to Study High-Impact Weather
Objective 1
Scatterometer/Ground Radar Comparisons
(Lang/Chronis)
monthly coordination telecons
Objective 2
Global Precipitation Systems
(Nesbitt/Student)
Doppler/Dual-Pol
NAME
DYNAMO
CPOL/KPOL
WSR-88DP
Scatterometers
SeaWinds
ASCAT A/B
OSCAT
RapidScat
Precipitation
TRMM/GPM
CMORPH/IMERG
Reanalyses
MERRA
Year 1
Build Database
Test Methods
Year 2
Organized
Tropical Precip
Year 3
Warm Season
Mid-Latitude
Year 4
Cold Season
Mid-Latitude
Year 1
Build Database
Test Methods
Year 2
Objective 1
Comparison
Year 3
Organized
Tropical Precip
Year 4
Mid-Latitude
Cyclones





Objective 1 in a Nutshell

Merge ground-based polarimetric Doppler radar data and surface buoys with scatterometer

Study how well scatterometers depict mesoscale wind fields near significant precipitation systems

Objective 1 Methods

- Use legacy scatterometer and field campaign datasets to build bridge to ongoing/future observations (ASCAT/RapidScat & WSR-88DPs/Buoys)

- Focus on polarimetric Doppler radars to build from previous work by the community using ground radar reflectivity only

Surface Radar Dataset	**Period of Coverage**	**Available Scatterometers**
NAME (S-PolKa)	Jul-Aug 2004	QuikSCAT/SeaWinds
DYNAMO (S-PolKa & assimilated wind maps)	Oct-Dec 2011	ASCAT-A, OSCAT
Darwin, Australia (CPOL) *Collaborator: B. Dolan, CSU*	~1100 days during Nov 1999-Apr 2007	QuikSCAT, ADEOS-II/SeaWinds, ASCAT-A
Kwajalein, RMI (KPOL) *Collaborator: D. Marks, GSFC*	Aug-Nov 2011 (high-quality dual-pol data)	ASCAT-A, OSCAT
TiMREX (S-PolKa)	May-June 2008	QuikSCAT, ASCAT-A
Coastal/Island WSR-88DPs	2011-Onward	ASCAT-A/B, OSCAT, RapidScat

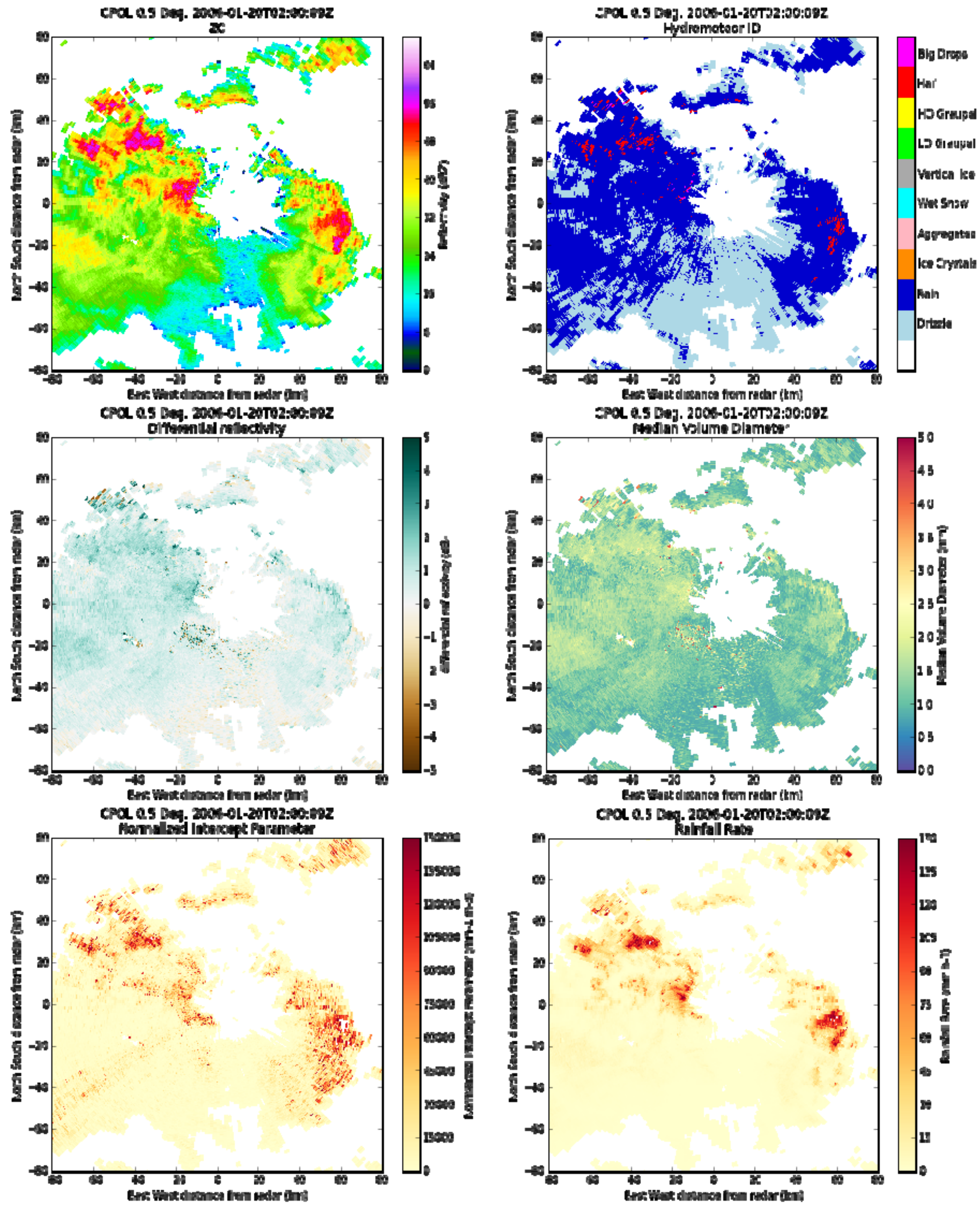
Polarimetric Radar Analysis

All-in-one object-oriented Python package (DualPol) that works with any C/S-band radar (currently being open sourced thru NASA)

Leverages ongoing collaborations with DOE (Py-ART) and Colorado State Univ. (CSU_RadarTools)

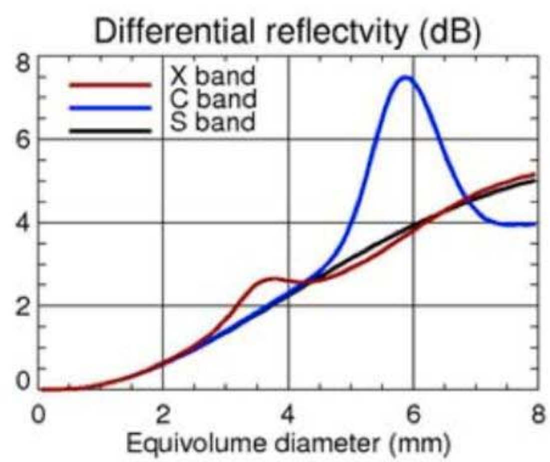
<u>Products</u>

- Blended rainfall estimation algorithm
- Hydrometeor Identification
- Drop-Size Distribution (DSD) Retrievals
- Liquid/Ice Discrimination and Water Content
- Improved Data QC

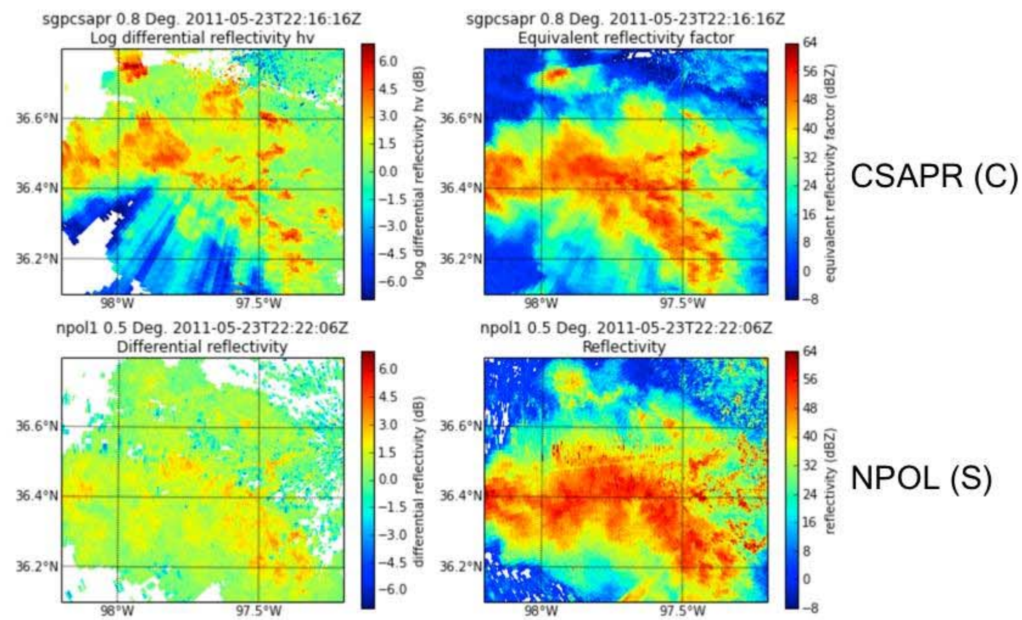


Benefits of polarimetric radar comparisons for scatterometry

- More accurate rainfall estimates than Z-R
  - Attenuation and surface roughness effects
- Mixed-phase and ice/snow identification
  - Wet ice = highly efficient attenuator
  - Dry snow much less attenuation than liquid water
- Rainfall Drop-Size Distribution (DSD) Information
  - More accurately characterize attenuation
  - Identify C-band resonance in regions of large drops
    - Implications for ASCAT



Ryzhkov and Zrnic (2005, AMS Radar)



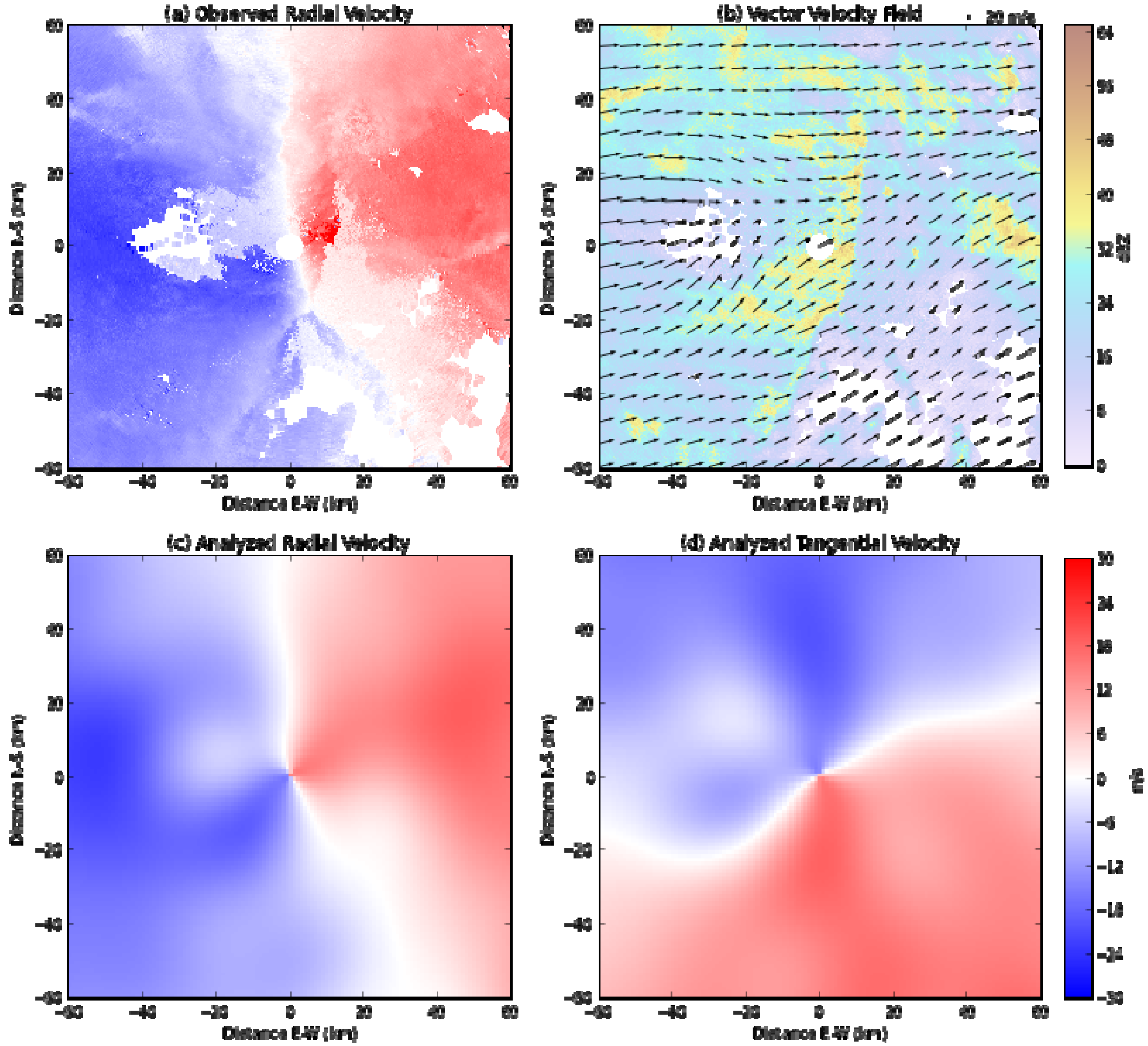
Single-Doppler Retrieval of 2D Low-Level Winds
(Xu et al. 2006)

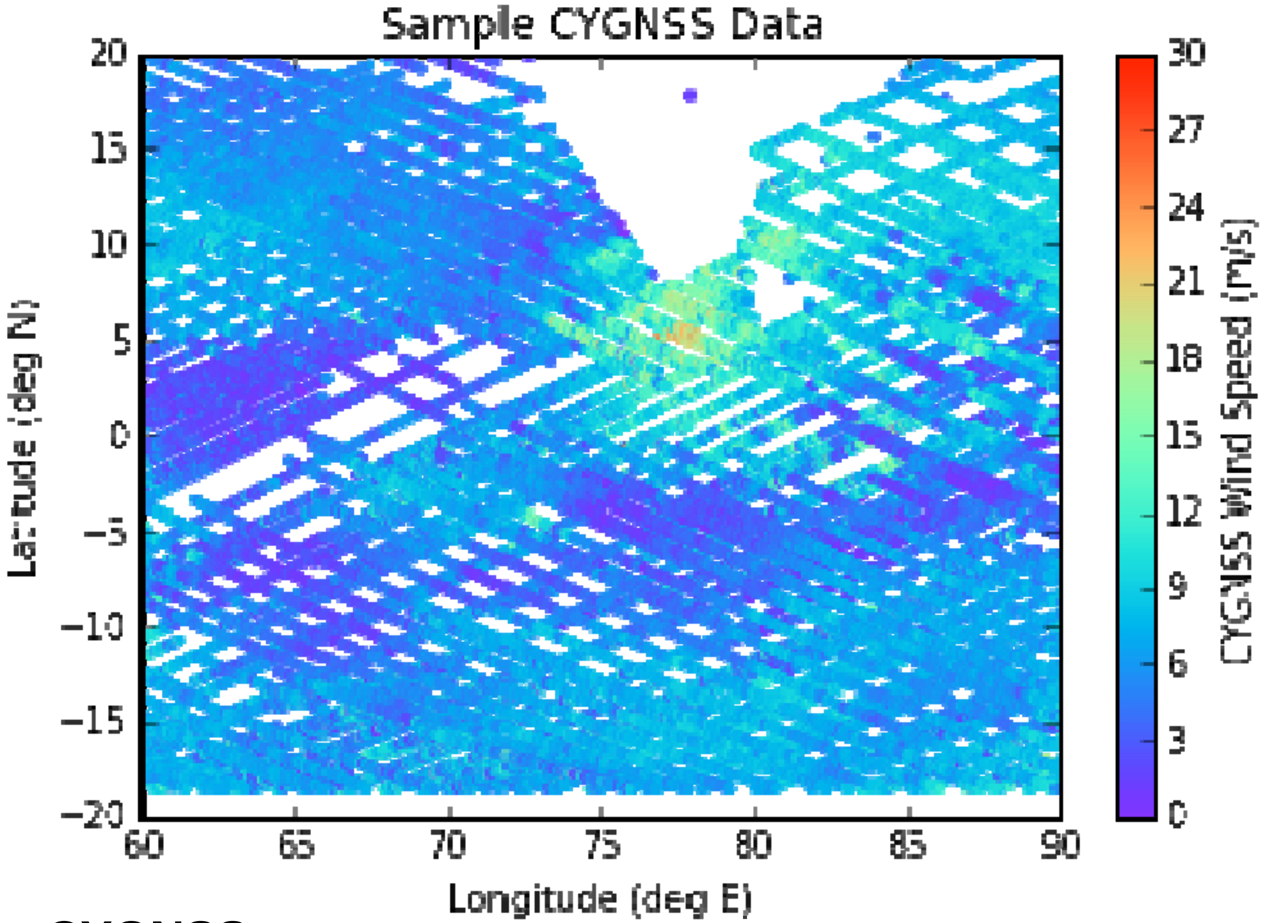
Use statistical interpolation to fill in radial Doppler velocity gaps and also estimate tangential wind component

Similar errors to scatterometers

Can resolve mesoscale features in heavy precip

Object-oriented Python module (SingleDop) undergoing NASA open source process



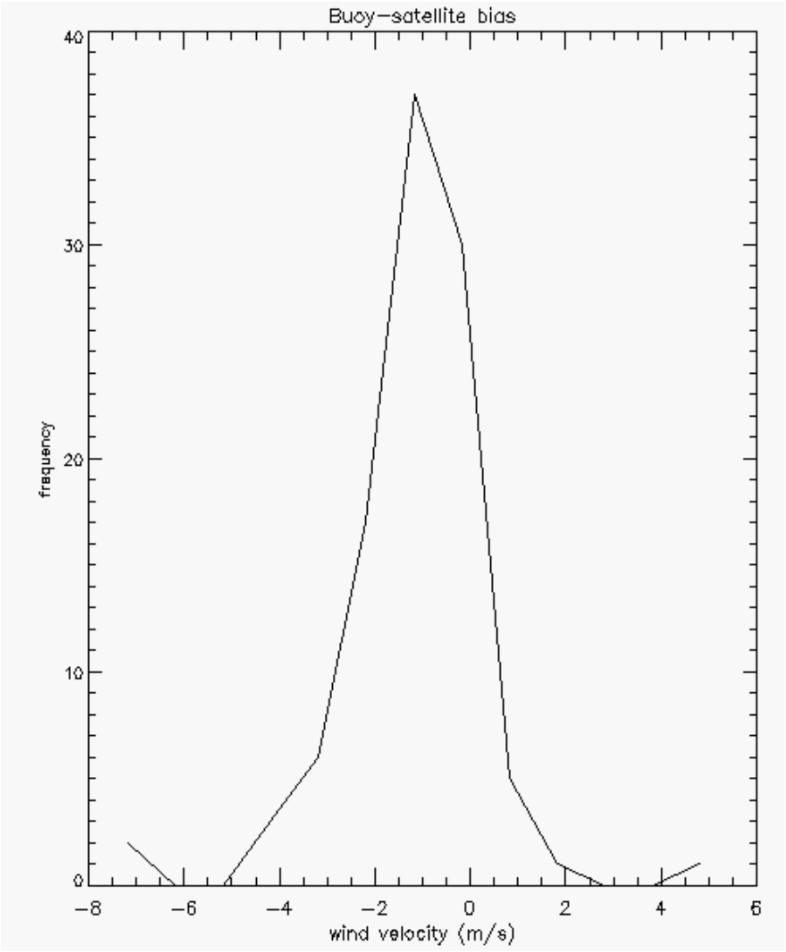


Leveraging CYGNSS

- Ongoing radar data assimilation from DYNAMO field campaign (2011)
- Producing WRF-based wind analyses w/ and w/out ASCAT/OSCAT input
- CYGNSS End-To-End Simulator to create synthetic CYGNSS observations

BUOY - ASCAT

- Data for June, July and August 2014
- Data buoy lat = 28.522N lon= 80.188W
- 102 coincident points for wind velocity > 5 m/s



Distance between buoy and satellite:

- Mean dist.: 0.34667
- Max dist.: 1.85
- Min.: 0.01

- 13 points with velocity < -2 m/s
- 2 points with velocity > 2 m/s

Buoys will be used to supplement radar/scatterometer analysis

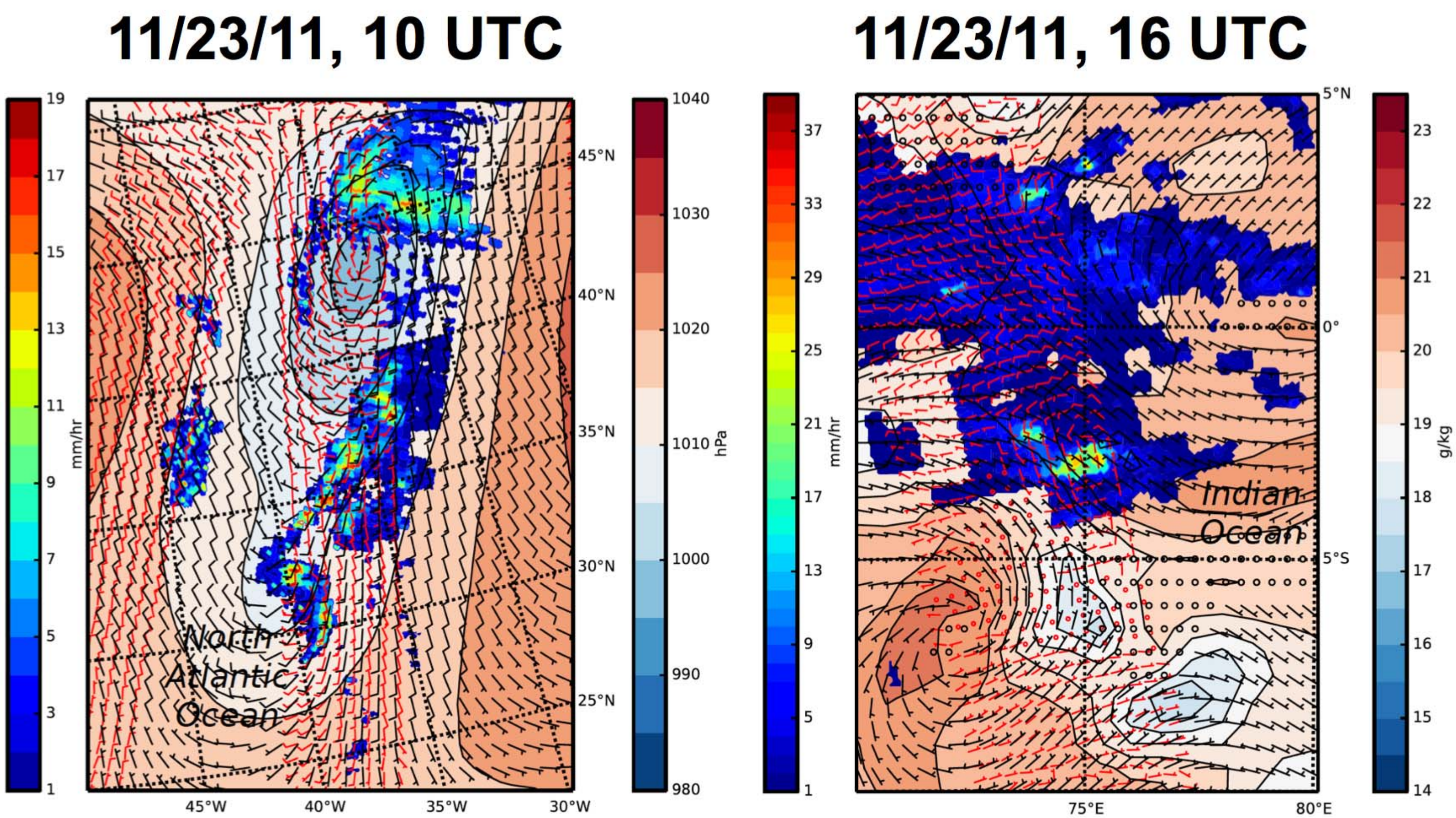
Objective 2 – Global precipitation systems

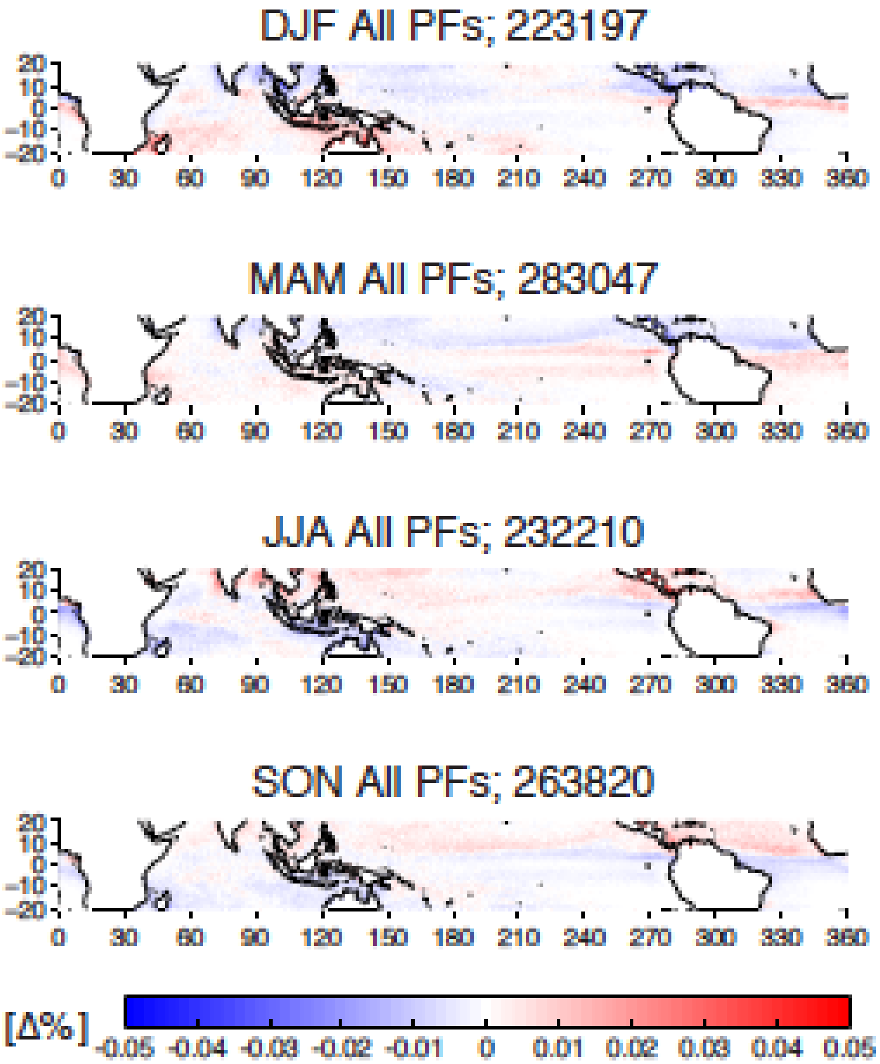
QUESTIONS

- What distinguishes tropical convective systems that produce extreme rainfall over their life cycle?
- What surface wind features are associated with these events including low-level jets, surface convergence zones, mesoscale vorticies, etc?
- How do the locations of heavy precipitation centers depend on surface airflow, and how do these characteristics vary as a function of location and season?

Objective 2 Merged Dataset

- Scatterometers (ASCAT, OSCAT, RapidScat)
- Satellite precipitation (CMORPH, then IMERG)
- Reanalysis data (MERRA)





Examine CMORPH Precipitation Feature dataset, select top 10% rain producers (~1 million PFs)

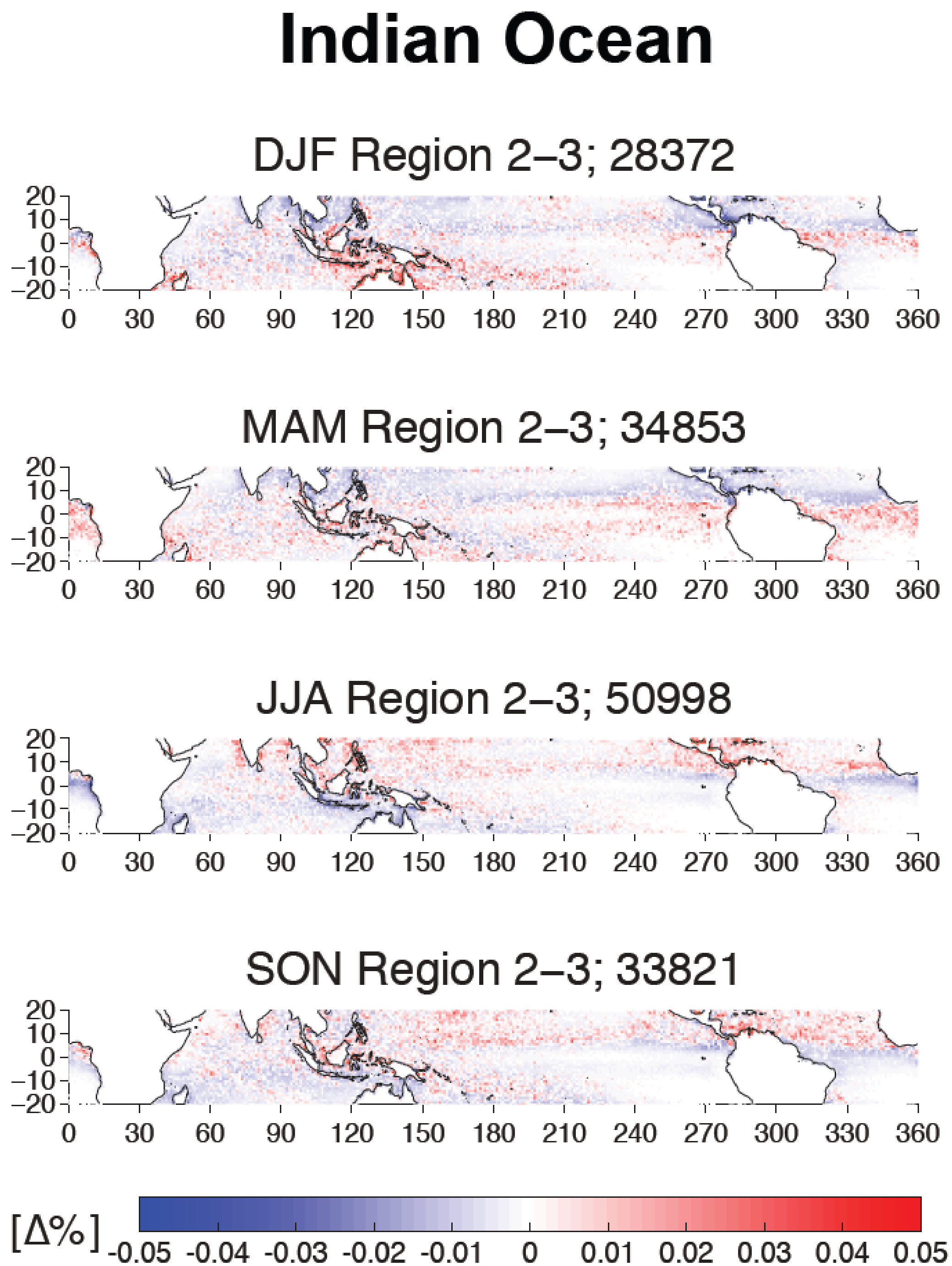
- Total, and seasonally-decomposed PFs demonstrate enhanced rainfall over coastal regions.

Sea/land breeze interactions?

Extreme PFs also modulated by intraseasonal oscillations (e.g., MJO)

Next step – bring in the scatterometer observations to examine 10-m wind behavior in and near these extreme PFs

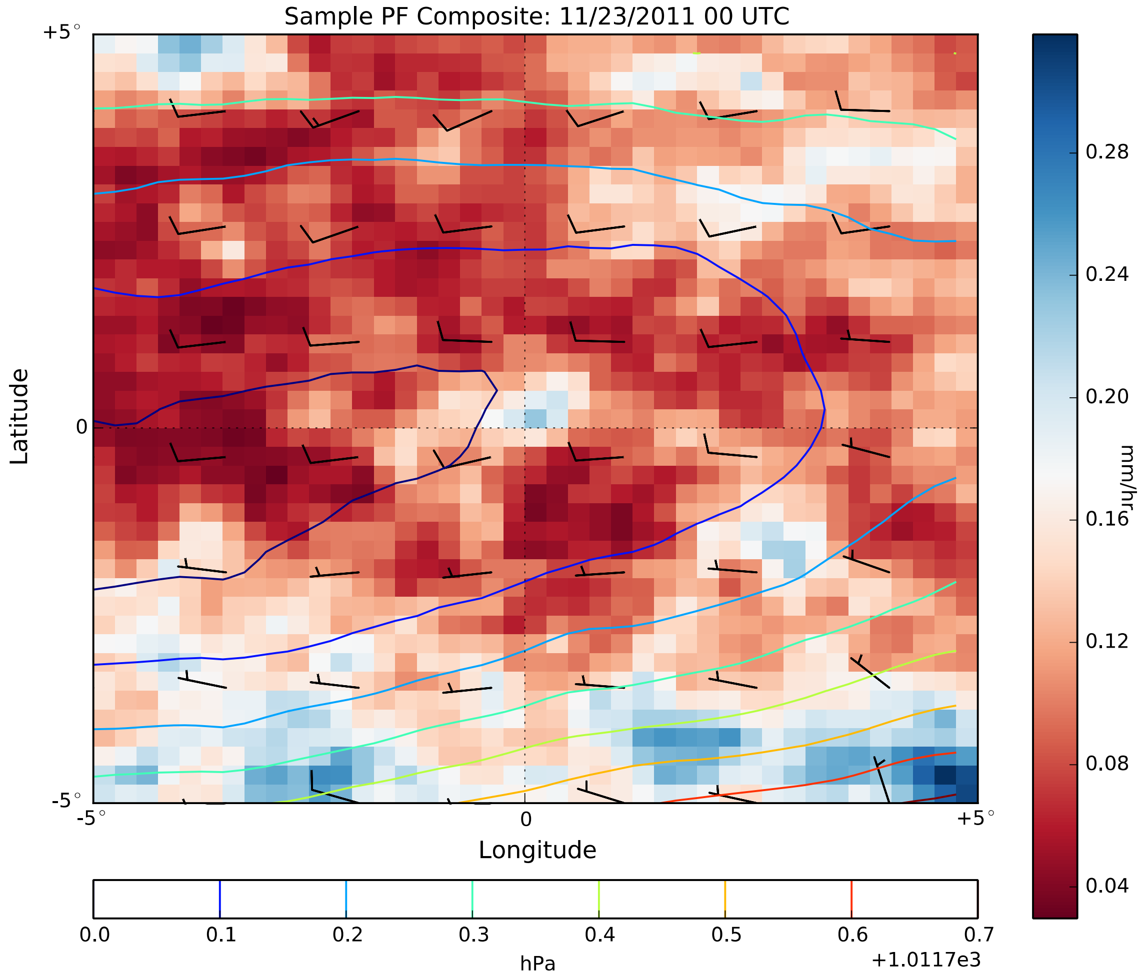
Analysis will be informed by Objective 1, which will tell us how well we can trust the scatterometers to identify mesoscale flow features important for system organization



Compositing Methodology

- CPC MORPHing technique (CMORPH) - 3-hourly, 0.25 degree resolution global rainfall data.
- Identify precipitation features (PFs) by their rainfall-weighted centroids.
- PFs are restricted to the tropics (+/- 20 degrees), and must be at least 4 pixels in size.
- Each PF is collocated with advanced scatterometer (ASCAT) surface vector wind data
- Composites created +/- 5° from each PF’s weighted centroid, where ASCAT overpasses exist.
- Sea level pressure data from the Modern Era Retrospective-Analysis (MERRA) matched with PFs

First Test PF Composite



- CMORPH precipitation, MERRA SLP at 11/23/2011 00 UTC
- ASCAT overpasses within 3 h of 00 UTC collocated with PFs
- PFs with ASCAT data used for average composite (above)

SUMMARY

Progress to date

- Radar analysis modules constructed
- Framework for scatterometer/ground radar/buoy comparison near completion
- Framework for merging scatterometer, satellite precipitation, and reanalyses near completion
- Two conference presentations (AGU Fall Mtg and AMS Python)
- Two additional conference abstracts submitted (AMS Radar)
- Two NASA New Technology Reports

Year Two Plans

- Finalize frameworks
- Identify Objective 1/2 combo cases (satellite + ground)
- Focus: Tropical precipitation systems
- Analysis!